

Note on the Paper by T. R. Merton on "Attempts to Produce the Rare Gases by Electric Discharge."

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The apparatus used by Mr. Merton in the above-mentioned paper was very kindly handed over to the author. The following experiments were made with it:—Five grammes of metallic uranium were finely powdered in a steel mortar and then heated to redness in a water-pump vacuum for half an hour. The metal was then transferred to a small bulb in which the metal could be bombarded with the cathode discharge, and this tube sealed on to the Merton apparatus. A small bulb containing charcoal, a hard glass tube containing copper and copper oxide, and a small bulb with phosphorus pentoxide were also sealed on to the apparatus. The whole was then pumped out and washed out several times with oxygen till the spark would not pass in the tube containing the uranium. The tube was then heated as strongly as possible and the gases pumped off and examined; carbon gases and hydrogen were present, but only just enough helium and neon to detect them in the ordinary way using a capillary tube. The tube was again washed out with oxygen and pumped till the spark would not pass through the tube containing the uranium. The palladium tube was then heated for about 20–30 seconds so as to admit hydrogen and allow the spark to pass. The bombardment of the uranium lasted about two hours. During all this time carbon gases and hydrogen were evolved from the metal. These were absorbed by keeping the charcoal bulb cooled in liquid air and heating the copper oxide. At the end of *Experiment 1* enough helium and neon at about 2 mm. pressure remained to fill the capillary examining tube and also a small space below.

Experiment 2.—Bombardment for one and a-half hours. Rather less helium and neon. (The helium lines—red, yellow, and green—not so strong as in *Experiment 1*.)

Experiment 3.—Bombardment for one and a-half hours; same result as in *Experiment 2*; the capillary tube filled with neon and helium.

Experiment 4.—Bombardment one and a-half hours. After the experiment the charcoal bulb was heated and the copper oxide tube also heated, and only the phosphorus pentoxide tube cooled. Other gases than carbon dioxide and water vapour would therefore not be condensed. The uncondensed gases in the capillary tube gave the nitrogen spectrum; after the

nitrogen had been got rid of by sparking above the mercury, the whole capillary, as before, was left full of neon and helium, and just enough argon to show the blue spectrum. In this experiment and all the following ones, before beginning the bombardment of the uranium, mercury was run up to the top of the capillary, showing that no gases remained in the apparatus from the former experiment.

Experiment 5.—Bombardment one and a-half hours. Result the same as in Experiment 4, but by continual sparking to get rid of the nitrogen (nitrogen combines with the mercury under these conditions) the capillary tube pitted round the platinum electrode and finally cracked.

Experiment 6.—A new bulb and new capillary tube were sealed on to the apparatus, which was carefully heated and washed out with pure oxygen till on running up the mercury into the capillary all gas disappeared on sparking. After the bombardment of one and a-half hours was over, before taking the charcoal out of the liquid air the mercury was run up to the capillary and the usual amount (namely, the whole of the capillary) of neon and helium was found. The charcoal was then taken out of the liquid air and heated and the copper oxide tube heated, and the phosphorus pentoxide tube cooled in liquid air. The remaining gases, as before, now consisted of neon, helium and nitrogen, with just enough argon to show (after the nitrogen had been removed by sparking), but the volume was the same as when only neon and helium were in the capillary tube.

Experiment 7.—Bombardment one and a-half hours. The result was exactly similar to the preceding experiment.

Experiment 8.—A repetition of No. 7, with the same result.

Experiment 9.—In all the former experiments a coil giving a 10-inch spark with a platinum break was used. A bigger coil with a mercury break was now employed. The bombardment was for one and a-half hours. Neither neon nor helium could be detected in the residual gases.

Experiment 10.—The old coil with the platinum break was again used; before, however, the residual nitrogen could be got rid of by sparking through the capillary tube, pitting occurred and the tube broke.

Experiment 11.—A new capillary tube was sealed on, and after an hour's sparking with the old coil neon, helium, nitrogen, and a trace of argon were found as before.

In all the above experiments the charcoal was strongly heated between each experiment and the apparatus washed out with oxygen made by heating permanganate of potash in a tube sealed on to apparatus. The pump employed always held a green phosphorescent vacuum from day to day.

During all these experiments the gases in the tube were entirely cut off

from the stopcocks during the whole of the experiment. Moreover, if the neon and helium found were due to an air leak, it is difficult to account for the disappearance of the argon, which should have been present to the extent of one thousand times as much as the neon and helium found. The amount of argon present, however, was too little to be measured, as it made no difference in the volume of the neon and helium (*cp.* Experiments 6, 7, and 8). The presence of the nitrogen is probably due to a nitride of uranium. The author, however, has only been experimenting with the apparatus for less than a month, and in work of this sort experiments must be repeated more than once before reliance can be placed on them; but that comparatively large amounts of neon and helium should come off from uranium by bombardment with the cathode rays, and not by heating, is a matter of interest; also that in one experiment a change of coil should affect the result is an observation that must if possible be repeated.

That the presence of neon and helium in vacuum tubes, after the electric discharge has been passed, is due to an air leak seems most improbable. Where the gases come from has yet to be proved. They have been found by Sir J. J. Thomson, by Sir W. Ramsay, by Mr. G. Winchester,* and by the author, Mr. Patterson, and Mr. Masson. Mr. Winchester is of the opinion that they are in some way occluded in the metal of the electrodes, and are not disintegration products of other elements. Whatever the source may be, it is only by further experiments that the question will be solved. The author hopes shortly to publish a more detailed report on the work done on this subject in conjunction with Mr. Patterson and Mr. Masson. He also wishes to thank Mr. Merton for the most useful apparatus with which the experiments were made.

* George Winchester (Physical Laboratory of Washington and Jefferson College), 'Physical Review,' N.S., vol. 3, No. 4, p. 287, April, 1914.